BBC RD 1976/33

Engineering Research Report

The work covered by this report was undertaken by the BBC Research Department for the BBC and the IBA

UHF field strength measurement of the ATS-6 satellite

J. Middleton, B.Sc.

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION December 1976

BBC RD 1976/33
UDC 621.396.946
621.317.328

UHF FIELD STRENGTH MEASUREMENT OF THE ATS-6 SATELLITE

J. Middleton, B.Sc.

Summary

Space technology can now provide a geosynchronous satellite capable of radiating over 100 kW e.i.r.p. within the UHF band. Therefore, the question of interference to existing or planned television services sharing this band merits investigation whenever an opportunity arises. The report describes a series of measurements undertaken to establish whether the ATS-6 UHF aerial used for transmitting an educational television service to India, had the specified directional properties. In particular it was confirmed that the maximum flux density at the earth's surface was restricted to below the value prescribed by the WARC-ST (Geneva 1971), namely -129 *dB*(W/m^2)*, which was the provisionally agreed figure for protecting reception of broadcasting stations.*

Issued under the authority of

G D Monteath

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

December 1976

(RA-154)

UHF FIELD STRENGTH MEASUREMENT OF THE ATS-6 SATELLITE

Section	Title	Page
	Summary	Title Page
1.	Introduction	1
2.	Interference aspects	1
3.	The estimated field strength	1
4.	Measuring the signal	1
5.	Conclusions	2
6.	Acknowledgements	3
7.	References	3
	APPENDIX 1: Receiving system parameters	4

© BBC 2005. All rights reserved. Except as provided below, no part of this document may be reproduced in any material form (including photocopying or storing it in any medium by electronic means) without the prior written permission of BBC Research & Development except in accordance with the provisions of the (UK) Copyright, Designs and Patents Act 1988.

The BBC grants permission to individuals and organisations to make copies of the entire document (including this copyright notice) for their own internal use. No copies of this document may be published, distributed or made available to third parties whether by paper, electronic or other means without the BBC's prior written permission. Where necessary, third parties should be directed to the relevant page on BBC's website at http://www.bbc.co.uk/rd/pubs/ for a copy of this document.

UHF FIELD STRENGTH MEASUREMENT OF THE ATS-6 SATELLITE

J. Middleton, B.Sc.

1. Introduction

The geosynchronous satellite ATS-6 was launched in May 1974 and among the many activities planned for its five years in orbit was the year-long Satellite Instructional Television Experiment (SITE). The objective of SITE was to demonstrate the capability of broadcasting via satellite to small receiving stations located throughout a large geographical area, in this instance India. It would then be possible to assess the potential value of satellite technology in establishing effective mass communications and instruction to developing countries.

By mid-1975 the satellite was in a geosynchronous orbit position above longitude 35 degrees East from where it could relay educational television material, sent by an uplink at 6 GHz from a ground station in India, to the whole of the sub-continent. The transmission from the satellite comprised a monochrome 625-line vision signal with two FM sound channels on 5·3 MHz and 6 MHz sub-carriers, all frequency modulating an 860 MHz main carrier to a maximum deviation of ± 8 MHz. It was thought by members of the European Broadcasting Union that this signal might cause interference to u.h.f. television in Europe and that field strength measurements should be made accordingly. Broadcasting authorities involved in the measurement programme were RTB/BRT (Belgium), BBC (England), TDF (France), RTE (Ireland), RAI (Italy) and NOS (Netherlands). The present report covers only the BBC activity.

2. Interference aspects

The effect of f.m. television on vestigial side-band a.m. television for overlapping r.f. channels has already been examined.[1] In 1971 at Geneva, the World Administrative Radio Conference for Space Telecommunications (WARC-ST) recommended, on a provisional basis, that the maximum power flux density produced at the surface of the earth within the service area of a terrestrial broadcasting station should not exceed -129 dB(W/m^2) in the band 620 MHz to 790 MHz, which is equivalent to a field strength of 17 dB(μV/m). This is for a circularly polarised signal from the satellite with an arrival angle of no more than 20° above the horizon.

At angles greater than 20° it is assumed that receiving aerial directivity would contribute to reducing the level of the unwanted signal. For example, at 60° or more a field strength of 33 dB(μV/m) would be acceptable.

Mention should be made at this stage of CCIR Report 631 which includes the UK submission, based on BBC experiments,[1] that the flux-density limit should be lower, namely -138 dB(W/m^2), corresponding to 8 dB(μV/m).[2] On the other hand, in the same report, the USA accepted a lower picture quality and submitted that -125 dB(W/m^2) or 21 dB(μV/m) should be the limit. In fact there was considerable disagreement between the various administrations regarding a value to adopt for protecting terrestrial television.

The angle of elevation in the South of England to the ATS-6 satellite is about 22° so that only if the field strength were to be above 17 dB(μV/m) could interference be expected, according to the WARC-ST, 1971, criterion. However, some margin is desirable in view of the findings described above. Even so, only the top of Band V would have been affected by the SITE transmission, in particular channel 68, which is a P4 allocation to the Midhurst station.

3. The estimated field strength

The transmitting aerial on the satellite is a 30 ft. dish with a 3 dB beamwidth of 2·8° and an e.i.r.p. of 52 dBW. Not much is known about the side lobes but CCIR report 215-3 suggests that, for a satellite transmitting aerial with this beamwidth, there should be at least 25 dB discrimination available 10° off the main beam.[3] This is the angle between Southern England and the satellite aiming point Nagpur, subtended at the satellite.[4] Hence the e.i.r.p. in the direction of England should not exceed about 27 dBW. The satellite to earth distance[4] involved is 39,330 km giving a predicted maximum free space field strength of about 10 dB(μV/m) in Southern England.

4. Measuring the signal

To measure the signal, use was made of a 17 ft. parabolic reflector belonging to the Royal Aircraft Establishment (RAE) at Lasham in Hampshire and fortuitously located near to the Midhurst service area. This reflector had previously been used at 220 MHz consequently the construction of a new feed aerial was necessary in order to operate at 860 MHz. For this a helical design was used, since it was both easy to construct and catered for the circularly polarised signal from the satellite. Details of the helix are given in Appendix 1. It was designed to illuminate the dish so that there was a 26 dB taper across the aperture from the centre to the edge.[5,6] This would result in a high gain aerial with low amplitude side-lobes to minimise the effects of ground reflections.

The resulting combination of reflector and feed is shown in Fig. 1 and had a gain of about 26 dB relative to a half wave dipole and a 3 dB beamwidth of about 4°. It was followed by a two transistor pre-amplifier with a gain of 23 dB which fed a standard crystal controlled Research Department field strength receiver aligned to work at 860 MHz and connected to a chart recorder.

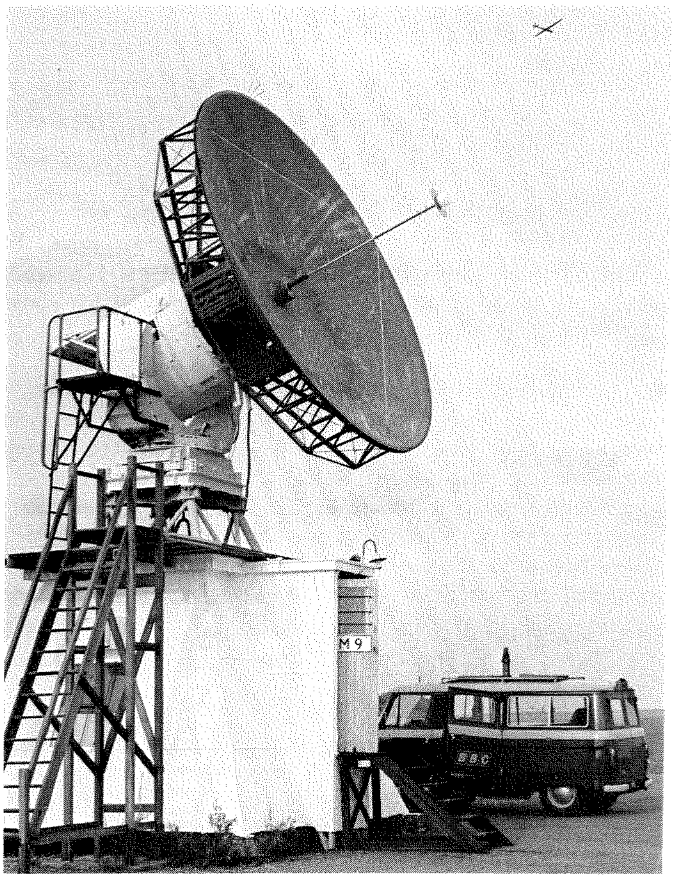

Fig. 1 - The receiving aerial at Lasham

The system gain was measured by setting the aerial to 0° elevation and illuminating it with a field of known intensity from a distant source, i.e. a source outside the "near field" region.

Once the parameters of the system had been established (See Appendix 1) the aerial was elevated to 22° above the horizon and rotated onto a bearing of 137° ETN, the direction of the satellite.

It will be seen from a sample of chart shown in Fig. 2, that at the start of transmission there was a period when the signal was at constant amplitude. This corresponds to a test card or some other stable transmission and gave an opportunity to adjust dish elevation and azimuth for peak signal before it was locked in position. The main programme then followed. However, the receiver passband was only ± 60 kHz and, with the wide-band FM signal from the satellite, the receiver output varied with picture content. This problem had been expected and also affected most of the other members of the EBU who were concerned with the measurement of ATS-6. In fact negotiations were undertaken by the EBU Technical Centre with the Indian Space Research Organisation (ISRO) in order to obtain the emission of a special test signal, possibly consisting of a 1 kHz tone with a deviation of ± 50 kHz.* However, the EBU was unsuccessful and the assumption had to be made that under certain modulation conditions the output of the receiver would approximate to that obtained with plain carrier. Measurements were made in October 1975 and again in March 1976 making a total of 28 days recording. The peaks correspond to periods when the modulation is low and will at least give some indication of the maximum signal likely to be received. Out of the two measurement periods the highest recorded field strength was 9 dB(μV/m).

During the second period of measurement the signal was also examined on a spectrum analyser with a scan bandwidth of 300 kHz. Photographs of the display are shown in Fig. 3 and demonstrate how the maximum energy is not always centred on 860 MHz. (Hence the problem with a narrow bandwidth recording receiver). The maximum level shown here corresponds to a field strength of 6 dB(μV/m).

5. Conclusions

The lack of plain carrier or a suitable calibration test signal for field strength measurement purposes was unfortunate, since changes in propagation conditions, transmitter power, or the effects of local weather were masked. The obvious alternative would have been to construct a

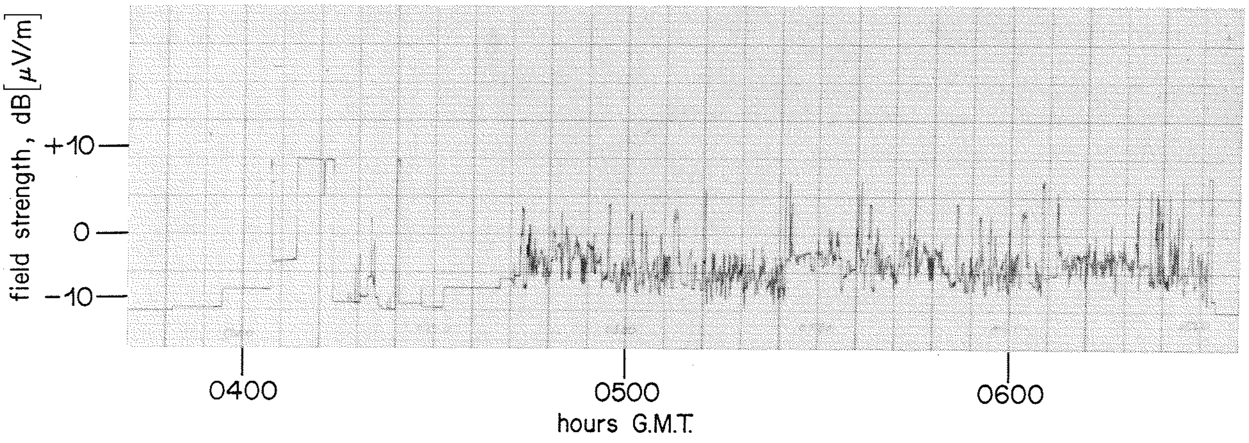

Fig. 2 - Field strength recording made at Lasham, 28th October 1975

---

* The transmission of plain carrier, which would have been ideal for these purposes, was not allowable according to the Final Acts of the WARC-ST (Geneva 1971).

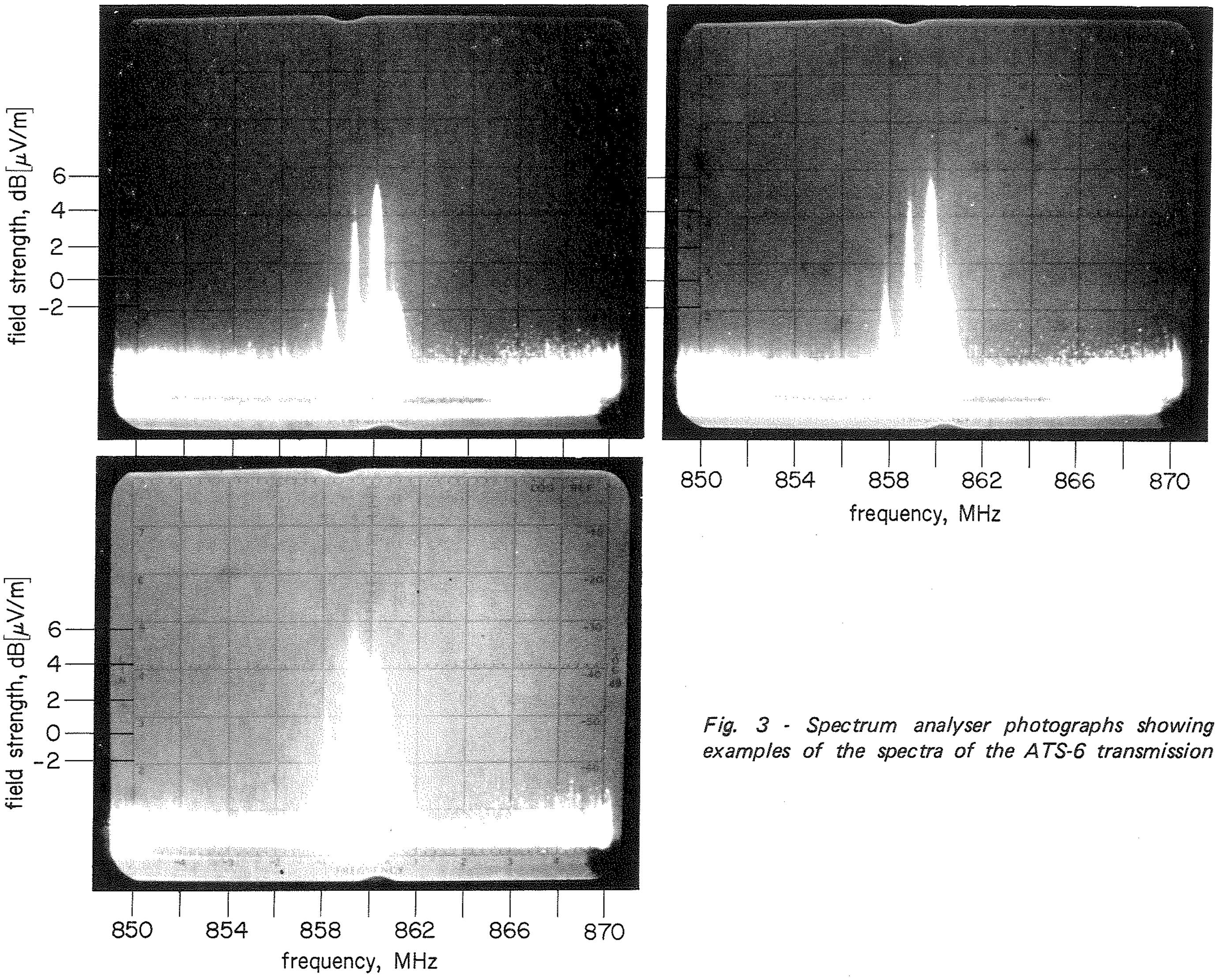

Fig. 3 - Spectrum analyser photographs showing examples of the spectra of the ATS-6 transmission

special wide-band recording receiver but other commitments prevented this being done in the time allowed. Even if such a receiver could have been used there would have been the need to use a higher gain aerial to avoid lower noise threshold limitations when receiving f.m. signals.

Nevertheless, it is possible to say, with a fair degree of confidence, that the field strength seldom, if ever, exceeded the estimated maximum value of 10 dB(μV/m) and that there was no danger of it reaching the level of 17 dB(μV/m) proposed by the WARC-ST for protecting terrestrial television networks, although it may occasionally exceed the value of 8 dB(μV/m) submitted by the UK in CCIR Report 631.

6. Acknowledgements

The assistance given by the RAE is gratefully acknowledged. In particular the help given by Mr. Stembridge, Mr. Hamshere and their staff, in preparing the 17 ft. dish at Lasham, was most appreciated. Thanks are also due to Mr. Blackband at Farnborough whose original offer to use the dish made these measurements possible.

7. References

1. BROWN, A. 1971. Protection ratios for 625-line system I television transmissions, impaired by interfering frequency-modulated television signals. BBC Research Department Report No. 1971/35.
2. CCIR XIIIth Plenary Assembly Geneva 1974, Vol. XI, Report 631, p. 217.
3. CCIR XIIIth Plenary Assembly Geneva 1974, Vol. XI, Report 215-3, p. 185.
4. SIOCOS, C.A. 1973. Broadcasting-satellite coverage-geometrical considerations. *IEEE Trans. Broadcast,* 1973, **BC-19**, pp. 84 – 87.
5. HOSKING, M.W. 1973. Microwave Antenna, *Wireless World*, 1973, **79, 1456**, pp. 501–555.
6. KRAUS, J.D. 1950. Antennas, McGraw-Hill, 1950.

APPENDIX 1

Receiving system parameters

1. Parabolic reflector with helical feed

Diameter	5·18 m
Focal length	2·297 m
Height a.g.l.	5·6 m
Gain	26 dB
3 dB Beamwidth	4°
Circumference of helix	0·279 m
Turn spacing	0·066 m
Number of turns	4

2. Pre-amplifier

Gain	23 dB
Noise factor	8·5 dB
Pass-band	400 MHz – 900 MHz
Feeder loss, aerial to pre-amplifier	1 dB
Feeder loss, pre-amplifier to receiver	2·5 dB

3. Receiver

Type	Research Department u.h.f. field strength recording receiver
Pass-band	± 60 kHz
Detector	Mean

4. Overall sensitivity

Minimum recordable field strength	-12 dB(μV/m)

HR

Printed by BBC RESEARCH DEPARTMENT, Kingswood Warren, Tadworth, Surrey, KT20 6NP